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ABSTRACT

In the Ely district, Nevada, gold, silver, tellurium, and mercury are distributed in zones clearly related to centers of alteration that are in turn related to the major copper deposits there. Recognition of similar zoning patterns elsewhere may be useful in exploring for ore deposits resembling those at Ely.

Locally, gold, silver, and tellurium are present in concentrations high enough to warrant further investigation or exploration in themselves. The district constitutes one of the largest occurrences of tellurium known in the United States.

INTRODUCTION

The porphyry copper deposits of the Ely district in east-central Nevada have been mined for more than half a century. Spencer (1917), Bauer, Breitrick, Cooper, and Swinderman (1964), and Bauer, Breitrick, Cooper, and Anderson (1966) studied the district and described a pattern of metal zoning having a core of relatively high concentrations of iron and copper surrounded by an envelope containing lead, zinc, gold, and silver in anomalous amounts. We have made additional studies to establish the geochemical setting of the copper deposits in greater detail and to determine the distribution and concentration of valuable metals such as gold, silver, tellurium, and mercury in the bordering areas or envelope. The information obtained may be useful in the search for concealed mineral deposits both in this district and elsewhere.

The eight geochemical maps accompanying this report (figs. 2-9) show the broad pattern of sampling and are designed to highlight anomalous concentrations of the principal metals of interest in this study (gold, silver, tellurium, and mercury), as well as of copper.

ANALYTICAL METHODS

Gold was determined by a wet chemical method (Lakin and Nakagawa, 1965) using atomic absorption spectrophotometry. Silver was determined by the emission spectrographic method as described by Ward, Lakin, Canney, and others (1963). Tellurium was determined by a sensitive wet chemical method (Lakin and Thompson, 1963). Mercury was determined instrumentally by an atomic-absorption technique (Vaughn and McCarthy, 1964). Limits of detection for these elements were: gold, 0.3 ppm (parts per million); silver, 1 ppm; tellurium, 1 ppm; mercury, 0.1 ppm. The analysts for gold were H. M. Nakagawa, K. W. Leong, and Arthur Hubert; for silver, Uteana Oda, G. C. Curtin, D. J. Grimes, and E. L. Mosier; for tellurium, J. B. McHugh, H. W. Lakin, C. E. Thompson, and Elizabeth Martinez; and for mercury, Henriette McCarthy, W. W. Janes, and H. W. Knight.

GEOLOGIC ENVIRONMENT

The Ely district is an area of Paleozoic sedimentary rocks intruded by quartz monzonite porphyry stocks of Cretaceous age. The sedimentary rocks, about 17,000 feet thick, are predominantly limestone and dolomite but include some shale and quartzite. They are divided into 17 formations (Brokaw and Shawe, 1965; Brokaw and Heidrick, 1966) but in figure 1 are grouped in only two units, pre-Pennsylvanian and Pennsylvanian and Permian.

The main ore deposits of the Ely district are in the central and western parts of a belt of altered and variously mineralized rocks about 1 mile wide that extends 8 miles westward from Ely (fig. 1). Another belt of altered and somewhat mineralized rocks extends about 3 miles northward from Ely.

The strongly mineralized western and central part of the main or west-trending belt coincides with a line of porphyry stocks. Rocks in parts of the stocks are much altered; and in extensive bordering areas, limestone was silicified or converted to jasperoid. Chalcopyrite and pyrite are disseminated in the porphyry and the altered or metamorphosed limestone. Ore bodies containing chalcocite formed by supergene enrichment of primary chalcopyrite-pyrite ore were important during the early years of mining, but primary chalcopyrite ore has been the principal source of copper for about 20 years. The central area had produced metals valued at nearly $1 billion by 1964 (Bauer and others, 1964); by far the largest production has been of copper, but appreciable amounts of gold, silver, platinum, palladium, and molybdenum have been obtained as byproducts; and some lead, zinc, and manganese have been mined.

The altered and somewhat mineralized belt trending north from the town of Ely approximately parallels a set of high-angle faults. It is a narrow belt characterized by partly to completely silicified limestone and dolomite and, as indicated by figures 2-9, by anomalous metal contents. The belt has not as yet been proved to be of economic significance, but it may reflect concealed ore deposits at depth.

MATERIALS SAMPLED

Most of the sampling was done in the central and eastern parts of the district because of the abundance of natural exposures and shallow prospect pits in those areas. Few samples were collected in the western part of the district, where copper has been mined, because most of the original outcrops have been concealed or destroyed as a result of mining activity. Samples collected were largely jasperoids with different colors and textures, gossans with different degrees of leaching, silica boxworks, fracture fillings, and limestones and dolomites with various amounts of silica boxwork or massive silica; some limestone and dolomite also were sampled.

The number of samples collected at each locality depended on the variations within the rock sampled. As many as 6 or 8 samples were collected at many localities but on the average 2 or 3 were collected; a total of 1,400 samples was collected within the district.

Nearly 400 samples were collected from the nearly continuous masses of jasperoid and gossan within the iron- and silica-rich zone of alteration in the central part of the district. Although the concentrations and proportions of metals within these materials are erratic, the samples collected probably are reasonably representative of the jasperoid.

Nearly 200 samples were collected within the north-trending eastern area. These samples were principally from partly silicified limestone and dolomite whose compositions range from low silica-high lime to high silica-low lime. The composition of these samples averages about 50 percent silica and 50 percent limestone and dolomite.

Many samples were collected outside these two alteration areas. Many of these samples were from apparently barren unmineralized rock, and some were iron- and manganese-rich fracture fillings or small pods of jasperoid and gossan, all representing small volumes of rock.

Two geochemical maps were made for each element (figs. 2-9), one map showing the average value of analyses of all samples at each locality and the other the highest value obtained at each locality. These maps also show, for the central and western areas, the limits of the iron- and silica-rich zone and the boundary of the area within which mineralized samples contain 0.5 percent or more copper. In the eastern area they show the limits of the zone within which limestone and dolomite are partly to completely silicified.

RESULTS

The analytical results show that gold, silver, tellurium, and mercury are generally enriched in the district as a whole, as shown in the following table and in figures 2-9. In some parts of the central and eastern mineralized areas, these metals are mostly concentrated in pods and dis-

	Abundance in igneous rocks (ppm)	*Average enrichment,[1] 372 samples from altered zone in central part of district*	*Average enrichment,[1] 88 samples of silicified rock from eastern part of district*	*Greatet enrichment[1]*
Tellurium	[2]0.002	33,100	85,500	5,000,000
Silver	[2].02	2,100	4,000	100,000
Gold	[3].002	655	150	16,500
Mercury	[2].06	3	613	1,160

[1] Enrichment $= \frac{\text{Concentration determined}}{\text{Abundance in igneous rocks}}$

[2] From Goldschmidt (1954).

[3] From DeGrazia and Haskin (1964).

	Area 1, 25 samples	Area 2, 40 samples	Area 3, 39 samples	Area 4, 69 samples
Tellurium	13.75	133	300	28.5
Silver	38	48	39	1.7
Gold	1.7	2.3	3.0	1.5
Mercury	.16	.14	.09	.1
Copper	3,200	1,600	2,100	1,100
Lead	925	1,300	3,300	75
Zinc	315	3,650	12,000	2,200

continuous masses of rock. Their concentration ranges from below the limit of detection to 10,000 ppm of tellurium, 1,600 ppm of silver, 33 ppm of gold, and 70 ppm of mercury.

In the central part of the district, the metals are generally most concentrated in a belt between the zone of high copper and the outer limit of the principal zone of alteration. The average concentrations of tellurium, silver, gold, and mercury in 372 jasperoid and gossan samples collected from this belt are given in the following table. For

	Parts per million	Ounces per ton
Tellurium	66.3	----
Silver	42.0	1.2
Gold	1.31	.038
Mercury	.19	----

each metal, about half of these samples contain values below the limit of detection. The higher analyses, with the exception of those for mercury, tend to be clustered near the quartz monzonite stocks. Outlines of four such clusters of high analyses are shown in figure 10. The concentration of the individual metals varies greatly from one cluster to another, as is illustrated by the table at top which shows the average concentration, in parts per million, of seven metals in each cluster.

In the eastern mineralized area silver, tellurium, and mercury are most concentrated within a narrow silicified zone. Most of the samples collected from this area are of boxwork silica or massive gray silica in incompletely to completely silicified limestone and dolomite. Samples of fracture fillings were largely iron- and manganese-rich oxides. All samples collected in this area are grouped and compared in the table at bottom (values given in parts per million).

Tellurium, silver, and mercury are higher in the eastern area than in any other part of the district, whereas gold is much lower. The ratios among the different metals are also different from those found elsewhere within the district. As compared to the central part of the district, the silver in the high-silica samples is higher by a factor of 2, tellurium by 2.5, and mercury by 200, whereas gold is lower by a factor of 5.

All the metals are more concentrated in the silica-rich material than in the lime-rich material although, surprisingly, silver is nearly as high in the average for all the samples as it is in the high-silica samples. However, the concentration of metals within the rocks in which they now occur does not seem to have been in proportion to the degree of silicification of the rocks. The table on page 4 (values in parts per million except as indicated) shows the random relation between the metals and calcium carbonate in 10 samples.

CONCLUSIONS

Gold is concentrated mainly in four local areas of high metal concentration as shown in figure 10;

	All samples except fracture fillings, 175 samples	High-silica samples (<5 percent Ca plus Mg), 88 samples	High-lime samples (>5 percent Ca plus Mg), 87 samples	Fracture fillings, 11 samples
Tellurium	85	172	7.2	38.8
Silver	71	80	52	85.9
Gold	.16	.31	.052	.27
Mercury	2.28	4.4	.09	7.0
Copper	1,350	2,200	500	2,624
Lead	1,660	2,500	1,124	4,253
Zinc	9,750	13,000	7,962	21,543

	Gold	Silver	Tellurium	Mercury	Copper	Lead	Zinc	Calcium carbonate [1] (percent)
315A	0.1	1	0.1	0.04	10	50	175	28
215	.1	100	1	.09	70	5,000	15,000	43
228	.1	1	.7	.08	5	10	25	43
227B	.1	1	2	.09	20	10	25	48
718	.1	1	.1	.02	50	200	40	65
780	.1	1	.5	.03	20	20	25	65
709	.1	5	.1	3	300	500	100	68
216	.2	5	.3	.05	5	300	1,000	90
719B	.1	1	.5	.01	20	100	25	92
211A	.1	5	.8	.01	200	700	1,000	95

[1] Calculated from the calcium content determined by X-ray fluorescence analysis. Margaret E. Hinkle, analyst.

the average gold content of samples from these four areas ranges from 1.5 to 3.0 ppm. Scattered high values of 6-11 ppm occur elsewhere, particularly near the east end of the central mineralized area.

Silver also is concentrated in three of the four local areas of high metal content shown in figure 10; in local area 4 no sample contained as much as 100 ppm, but samples from the north and northeast of it showed silver contents as high as 1,000 ppm. Many samples from the eastern mineralized area yielded 100-700 ppm silver. The combined content of silver and gold in samples from parts of the central area is within the range of economic value, and these areas may merit additional exploration.

Mercury is generally present in only very small amounts; most samples contain less than 0.5 ppm; and as shown in figure 9, only 16 samples yielded more than 5 ppm. Most of the samples with high mercury content are from the eastern mineralized area. Mercury in such low concentrations is of no direct commercial interest, but it is geochemically significant as a possible "indicator" of other metals, especially the precious metals. Its presence in amounts as high as 70 ppm in the eastern mineralized area may therefore be of economic significance.

On the basis of our sampling, it appears that relatively large volumes of rock in the Ely district contain on the order of 100 ppm of tellurium, or about 50,000 times the average abundance in igneous rocks. In contrast, the presumably tellurium-rich Cripple Creek, Colo., gold-telluride district contains an average of only 0.5 ppm of tellurium, based on 350 samples of surface rocks (unpub. data, U.S. Geol. Survey). The Ely district may contain the largest reserve of tellurium in the United States. At the current price of $6 per pound for the metal (Engineering Mining Journal, Sept. 1966, p. 24), tellurium could appreciably affect the economics of mining in parts of the district, particularly the eastern area.

Gold, silver, mercury, and tellurium form halos around a copper-rich core. In the central mineralized area, all these metals except mercury are greatly enriched relative to their average abundance in igneous rocks. In the eastern mineralized area, all are enriched, although gold is enriched only about one-fifth as much as in the central area. This zoning pattern suggests that, relative to each other, gold moved the least distance from the center of mineralization, silver and tellurium intermediate distances, and mercury the greatest distance. This being so, the eastern mineralized area might be expected to show increase in gold and copper with depth.

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